GIL079

General
Information Leaflet

Finding the best liquid chiller package

ACTIONenergy
From the Carbon Trust

If you buy or specify packaged liquid chillers, this information leaflet will help you save money. It shows you how to ensure you buy the most cost-effective package.

The type of chiller package you select will be dictated by the application and how the heat is to be rejected (i.e. to ambient air or water). There are numerous suppliers of both off-the-shelf and bespoke packages. This leaflet shows how you can compare the performance and lifetime costs of different packages and thus choose the most cost-effective and energy efficient option.

Factors such as build quality are not covered by this leaflet, but you should consider them when evaluating options.

Chiller types

Chiller packages are available for different applications (see Table 1). The heat can be rejected via water-cooled, air-cooled or evaporative condensers, with the condenser being either part of the package or mounted remotely. Some models are reverse cycle, i.e. they can provide heating when cooling is not required.

Water-cooled chillers are generally more energy efficient than air-cooled versions. However, for an accurate comparison of running costs, you need to take into account the costs associated with water treatment and cooling tower operation.The merits of water-cooled packages increase as the size of the system increases.

Table 1 Applications of liquid chiller packages

Application	Chilled liquid temperature
Process cooling	Up to 25ºC
Air conditioning	Between +2ºC and +15ºC
Medium temperature brine	Between -12ºC and +3ºC
Low temperature brine	Below -8ºC

Chiller efficiency

The efficiency of a chiller package depends largely on its design. In most cases, efficient packages:

- Are fitted with a large evaporator and condenser (to reduce temperature lift)
- Use the most efficient compressor(s) and refrigerant for the size and application
- Have an effective control system which optimises the operation of the compressor and fan motor
- Will either not operate with head pressure control or will minimise the head pressure setting.

The most efficient chiller package is not always the most expensive to buy and will usually cost less over its lifetime.

Some packaged chillers are fitted with economisers, which mechanically sub-cool the liquid refrigerant entering the expansion device, thus improving capacity and therefore efficiency. The efficiency benefit is most significant for low temperature applications.

If the ambient temperature is lower than the chilled fluid, it is sometimes possible to use 'free' cooling. This can be achieved by allowing refrigerant to circulate naturally without running the compressor, or by using cooling tower water in winter to chill the process directly, or by using a pre-cooling coil. Such technologies can improve efficiency by 25% or more. Systems that run at higher chilled water temperatures and which have a large heat load all year round are the most suited to free cooling. Typical applications include data processing centres, telecommunication rooms and chilled ceiling installations.

For more information about efficiency, see **GPG280 Energy efficient refrigeration technology — the fundamentals.**

Eurovent Certification

Valid and quick comparisons of chiller performance require chillers to be tested and rated under common conditions. The Eurovent Certification programme has developed a common set of criteria for chillers. Chillers that are certificated by Eurovent have been tested to the same standard and the accuracy of published data is assured. Further information is available on the Eurovent Certification programme website **www.eurovent-certification.com**

Part load operation

Chillers are selected and sized to handle the maximum heat load but, for most of the time, the heat load will be less and many chiller packages have some form of capacity control to meet a varying load.

Larger chillers are often fitted with multiple compressors, which are cycled to meet the load. This is more efficient than using one large compressor operating for much of the time on its in-built capacity control.

The method of capacity control can have a significant impact on efficiency – a chiller that has the best efficiency at full load may not necessarily be the best at 50% load. If the prevalent operating condition is part load, then the efficiency of the capacity control system is important.

The integrated part load value (IPLV) is a weighted average of efficiency measurements at various part load conditions. This can be used to make accurate and valid comparisons of chillers that operate at part load for a significant amount of time. It is currently specified in the US Air-Conditioning and Refrigeration Institute's standard ARI 550/590-98 and will be included in the Eurovent certification scheme in the future.

The process liquid circulation pump should also be considered. This consumes power directly, but also heats the chilled liquid, thus increasing the heat load on the chiller. Controlling the speed of liquid pumps when operating at part load can result in significant energy savings, as both direct and indirect energy consumption are reduced. For more information about pump motor operation, see **GPG002 Energy savings with electric motors and drives.**

Do not oversize chillers

Part load operation is inefficient. It is minimised if the chiller is the correct capacity.

Measuring efficiency

The energy efficiency of chillers is usually specified as the energy efficiency ratio. This is the best measure to use when comparing different chillers. For a reverse cycle chiller in heating mode, the coefficient of performance is used as the measure of energy efficiency.

The power input includes the compressor and the fan and pump motors associated with the chiller. The higher the EER or COP, the better the efficiency and the less the chiller will cost to run. When comparing options, it is important to include the power of the process fluid pump motor.

Performance measurements should be made at specific and consistent rating conditions to ensure valid comparisons. The rating conditions vary with different types of package (e.g. water-cooled and air-cooled). They ensure that the relative efficiencies are consistent when actual performance varies with different liquid and ambient temperatures. The measurements are made to the following standards: BS EN 12055 (cooling) and BS EN 255 (heating). More information is available from Eurovent.

Measures of efficiency

Energy efficiency ratio (EER) = $\frac{\text{Cooling capacity (in kW)}}{\text{Power input (in kW)}}$

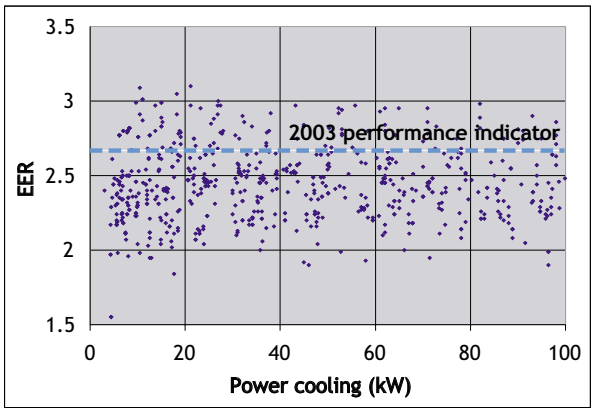
Coefficient of performance (COP) = $\frac{\text{Heating capacity (in kW)}}{\text{Power input (in kW)}}$

Information from UKEPIC

The product database held by the UK Environmental Product Information Consortium (UKEPIC) at **www.ukepic.co.uk** contains information about the performance of a wide range of standard liquid chiller packages. The database includes split and remote models that range in cooling capacity from 3kW to over 6,000kW. The energy consumption, EER and COP (where relevant) are provided together with other technical data. Figure 1, which uses information from UKEPIC, shows that the range of efficiencies is very wide, even for the same type of equipment.

Performance indicators have been set for packaged chillers to encourage manufacturers to increase the energy efficiency of their products. These indicators are based on EER or COP, and are set for the years 2003, 2006 and 2010. The targets are challenging but achievable, and progressively increase. The dashed line on Figure 1 shows the 2003 performance indicator (EER = 2.7).

Figure 1 EERs of packaged, air-cooled chillers up to 100kW capacity, for cooling only for air conditioning conditions



Source: UKEPIC

Life-cycle cost

The cost to operate a chiller during its lifetime is usually several times its capital cost. When comparing possible options, it is important to take operating costs into account before deciding to buy.

Life-cycle cost (LCC) = Capital cost + [Annual energy cost x Lifetime (in years)]

The capital cost includes the chiller, its installation and its commissioning. Servicing, maintenance and disposal costs are normally similar for the same type of chiller and have therefore not been included.

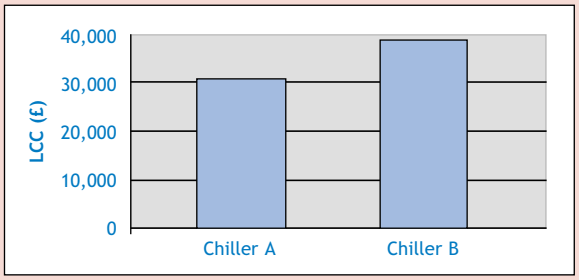
Example

The performance data for two 30kW packaged chillers of the same type are given in Table 2 and their life-cycle costs are shown in Figure 2. The chillers are both air-cooled, cooling only and for air-conditioning duty running on refrigerant R407C. The energy efficiency (as shown by the EER) of Chiller A is approximately 33% higher than that for Chiller B. Assuming a seven-year life, Chiller B will cost over £8,000 more than Chiller A (based on the chillers running at full load for 18 hours a day).

Table 2 UKEPIC details for the two chillers

Chiller	Capacity (kW)	Power input (kW)	EER
A	30.5	11.0	2.77
B	30.8	14.7	2.1

*Figure 2 Life-cycle costs for the two chillers**



**Assuming a seven-year life.*

Bespoke and standard chillers

Bespoke solutions are usually only used when a standard, off-the-shelf package cannot be found. However, bespoke solutions can be more efficient than standard alternatives. A bespoke design enables the manufacturer to select individual components to maximise the performance while maintaining the flexibility to meet other constraints arising from the installation environment. The utilisation of industrial components makes it possible to extend the life of the product and thus reduce its life-cycle cost significantly.

The advantages of the greater design freedom associated with bespoke packages include:

- The ability to size for closer approach temperatures and higher operating ranges
- Use of alternative control techniques to maximise the overall efficiency
- Use of the best refrigerant for the temperature range.

Bespoke chiller manufacturers should be able to supply the performance information required (to the same test standards and rating conditions as specified by Eurovent) to calculate their life-cycle costs and thus make accurate comparisons with standard packages.

Refrigerants

Under European regulations, it is now illegal to use R22 and other hydrochlorofluorocarbon (HCFC) refrigerants in most new systems. It will be illegal to use new HCFCs to service equipment from the year 2010.

To ensure the long-term serviceability of your chiller, you should specify hydrofluorocarbons (HFCs) such as R407C or natural refrigerants such as ammonia or propane.

Maintaining chiller performance

To ensure their performance does not deteriorate, chillers need to be maintained adequately and operated correctly. Inadequate maintenance will result in higher operating costs – energy use will increase and reliability will reduce (leading to higher reactive service costs).

The following list summarises good maintenance practice.

- Locate the chiller where it can be accessed easily for maintenance and servicing (in particular, ensure there is good access to air-cooled condensers for cleaning)
- Ensure the air onto air-cooled condensers, evaporative condensers and cooling towers is not restricted, recirculated or warmer than necessary
- Allow time for the chiller to be commissioned correctly
- Introduce a maintenance regime that includes as a minimum:
  - Cleaning the condenser
  - Checking for refrigerant leaks
  - Checking the operation of fans and pumps
  - Checking control settings
  - Checking compressor operation
  - Ensuring components and pipework are free of vibration
  - Ensuring that manufacturers' schedules of compressor service are followed on large chillers
- Do not set the chilled liquid temperature too low (this will make the overall power consumption higher than necessary).

For more information, see **GPG279 Running refrigeration plant efficiently — a cost-saving guide for owners.**

Tax breaks when buying listed energy efficient equipment

The Enhanced Capital Allowance (ECA) scheme allows businesses to deduct 100% of capital expenditure on energy efficient equipment against their taxable profits in the first year. This effectively reduces the total cost of the investment by 3-6% over ten years — another factor to take into account in any investment appraisal. The ECA scheme covers a wide range of technologies, and it is possible to claim tax relief in situations where:

- A qualifying item is bought standalone (i.e. capital cost, installation cost, professional fees and the cost of altering existing buildings)
- A qualifying item is bought as part of a non-qualifying system (e.g. a variable speed motor supplied with a standard pump), in which case the allowable claim values are as shown at **www.eca.gov.uk**

The Energy Technology List was set up to identify those products qualifying for ECA tax relief. Additionally, the products listed can help businesses and non tax paying organisations to identify energy efficient products and technologies that can save money on long-term operating costs. It currently features over 5,000 products and continues to grow on a monthly basis.

Energy efficient standard packaged chillers can be found on the Energy Technology List. For further information about the Energy Technology List and ECAs, visit **www.eca.gov.uk** or call the Action Energy helpline on **0800 58 57 94.**

Such purchases could be eligible for an interest free Action Energy loan. Action Energy Loans are aimed specifically at small and medium sized enterprises (SMEs). The £10 million Action Energy Loans scheme offers interest-free loans of between £5,000 and £50,000 to help SMEs buy energy efficient equipment to replace or upgrade existing facilities. Repayments are made over four years and the savings can often be greater than the loan repayments. The loan can also cover the cost of installing and commissioning the equipment. For further details on interest-free Action Energy Loans, call the helpline on **0800 58 57 94** or visit **www.actionenergy.org.uk**

Further information

Action Energy
0800 58 57 94
www.actionenergy.org.uk

UKEPIC performance database
www.ukepic.co.uk

Enhanced Capital Allowances
www.eca.gov.uk

Eurovent certification scheme
www.eurovent-certification.com

British Refrigeration Association (BRA)
01491 578674
www.feta.co.uk

Heating Ventilating and Air Conditioning Manufacturers Association (HEVAC)
01491 578674
www.feta.co.uk

Institute of Refrigeration
020 8647 7033
www.ior.org.uk

US Air-Conditioning and Refrigeration Institute (ARI)
www.ari.org

British Standards Institute (BSI)
www.bsi-global.com

Tel 0800 58 57 94

www.actionenergy.org.uk

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